INCREASING ENERGY EFFICIENCY IN NEW BUILDINGS IN THE SOUTHWEST

The Role of Energy Codes and other Efforts

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Southwest Energy Efficiency Project

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EXECUTIVE SUMMARY

Energy code adoption and enforcement in much of the Southwest is not far advanced, but progress is being made in all six of the states in which SWEEP is active. Areas without energy codes tend to fall into two classes: those in which a very small number of homes are being built, and those in which Energy Star® and other programs that promote energy efficiency are active and growing quickly. Further, in virtually all jurisdictions, there is movement to adopt or where adopted, increase efforts to enforce codes and educate the building community.

Energy codes can set the tone for energy efficiency, establish threshold criteria, affect the marketplace for both raw materials (e.g., windows) and finished products (buildings), and can be communicated to key actors (e.g, architects, engineers, builders), all at bargain-basement costs.

Codes define the minimum necessary toward achieving good energy performance, but they cannot ensure that first-rate buildings result. Stronger coordination between the code community and other entities like utility and government-supported efficiency programs will create natural synergisms in achieving the most important goal: fine, very energy-efficient buildings whose lifetime costs are substantially lower than the ordinary buildings that constitute most of current building stock.

Analyses in this report suggest that savings of well over 50% above base-case structures are not only possible but very cost effective. More important, studies of innovative programs throughout the Southwest illustrate that a large number of efficient buildings are being built in certain jurisdictions as a result of well-designed and implemented public/private partnerships.

After urging the passing and enforcement of up-to-date codes, our principal recommendation is to expand efforts to promote the construction of highly efficient new buildings that significantly exceed minimum code requirements.

SECTION 1

BUILDING CODES AND ACTIVITIES TO ACHIEVE EFFICIENCY IN BUILDINGS

The energy code process can be a powerful and effective pathway to achieving energy-efficient buildings: state-of-the-art building codes can contribute to the reduction of energy use in buildings by 15 to 30 percent or higher (Johnson and Nadel 2000, Kinney 2002). However, the path to achieving energy efficiency via the code process has both bumps and curves, and full savings potential is not easily achieved. Ideally, for a building energy code process to be successful, an aggressive but practical code must be developed—usually via modifying a version of an existing model code based on an ASHRAE or International Energy Conservation Code (IECC) standard—one that is understood by all parties, adopted through at least a quasi-consensus process, enforced, and, most importantly, exceeded by most builders. There are examples of successful code processes that have approached this ideal in the Southwest—and others where the reality in the field is substantially at variance with what's called for in the codes.

As described in the following paragraphs, there are two other categories that follow this good news, bad news pattern. Beginning with the bad news, there are areas where codes are non-existent or routinely ignored and where efficient new housing stock is the exception. Fortunately, most of these areas are not associated with substantial demand for new housing. There are other areas where no energy codes exist but which are in a building boom where market competition and a number of other forces are resulting in a preponderance of buildings whose energy performance is quite good. Accordingly, in the following, we first look at the patterns of code adoption and compliance in each state, describing current circumstances and relating what appears to be on the near horizon. Then we note other trends in the new building sector that point toward increasing energy efficiency.

ARIZONA

Status of Energy Codes

The most populous of the states in SWEEP's region, Arizona has the highest rate of increase in energy demand and is adding the largest number of new dwellings to the grid each year, well more than 50,000. Arizona has state legislation calling for the *voluntary* adoption of the 2000 IECC for residential buildings and ASHRAE 90.1-1999 for commercial codes statewide. However, since Arizona is a "home rule" state—which in practice means that it's quite difficult to pass state-wide energy codes that include concrete requirements for implementation—there are no readily-available mechanisms for applying pressure at the state level that could require local enforcement. Although there is movement toward getting codes on the books in most parts of the State—and many are already in place—the metropolitan area of Phoenix, the second fastest growing urban area in the nation (Atlanta is first), still has no energy code.

That said, Phoenix and its surrounding suburbs are working to adopt codes. Phoenix itself is looking to adopt a variation of the new comprehensive National Fire Prevention Association (NFPA) 5000 building code by mid-2003. NFPA includes ASHRAE Standard 90.2-2001 as a residential energy code and ASHRAE Standard 90.1-2001 as a commercial code. As of December 2002, the committee responsible for developing the new code in Phoenix had no changes associated with the energy portions of the NFPA code (McElvaney 2002). The present schedule anticipates public hearings in February and March and delivery of the recommendations to the Phoenix City Council by early summer.

The City of Tempe, which shares a common boundary with Phoenix, is also involved in a process aimed at adopting a residential energy code. Its city council has passed a resolution authorizing the citizens' committee examining the issue to consider both NFPA 5000 and the IECC. The adoption process is on hold awaiting the finalizing of the NFPA code. Actions by Phoenix may also influence Tempe's code adoption process.

In addition to the City of Phoenix, the Maricopa Association of Governments has a codes committee that meets monthly to consider adopting and implementing energy codes in all of the municipalities in the area. According to the League of Arizona Cities and Towns, four of the 25 cities and towns that are a part of MAG have adopted the 2000 IRC (which include the IECC by default) and more anticipate adopting it soon.

Tucson, which is also experiencing a housing boom, has the 1995 Model Energy Code (MEC) on the books and is in the final stages of passing IECC 2000. All parties are in agreement as of the fall of 2002, and formal adoption awaits action by the city council and mayor. According to Carl Rald, Tucson's Energy Programs Coordinator, adoption is likely early in 2003 (Rald 2002). In addition, 21 communities in the area around Tucson (Pima County) have in place IRC or IECC codes. Table 1-1 summarizes progress as of the fall of 2002:

Table 1-1. *Status of code adoption in Arizona, December 2002.*

City/Town	Code on Books	Anticipated Soon
Avondale	2000 IRC	
Goodyear	2000 IRC	
Phoenix		NFPA 5000 (July 2003)
Queen Creek	2000 IRC	
Scottsdale		IECC 2000 (2003)
Surprise	2000 IRC	
Tucson	MEC 1995	IECC 2000 (January 2003)
21 communities in Pima County	2000 IRC	

Other Efficiency Work

Happily, the absence of an energy code in Phoenix does not mean that all new dwellings are poor energy performers. The State Energy Office has been very active in promoting high-quality construction to builders in Phoenix, Tucson, and elsewhere. Charlie Gohman, Conservation & Engineering Manager of the Arizona Department of Commerce, has played a lead role in promoting energy efficient construction practices to Arizona's builders. A key part of this strategy has been to provide Arizona builders access to nationally-known trainers who preach the virtues of healthy, energy-efficient housing through holistic understanding of how homes work and attention to detail in insulating, air sealing, fenestration, and ventilation.

The strategy is clearly paying off. Now, there are over half a dozen enlightened production builders like Pulte who routinely build to Energy Star® standards and beyond.[1] A representative of an HVAC company that installs on average 120 new HVAC systems in the Phoenix and Tucson areas each working day estimates that at least half of the homes being built in those two areas are built to be very energy efficient homes. *(See "New HVAC Installs" sidebar below.)* Daren Wastchak, who runs a building energy inspection company, estimates that almost 6,000 of the 35,000 homes built in the Phoenix area in 2002 were Energy Star®-rated, and the market share is rising rapidly (Wastchak 2002). Indeed, Arizona builds far and away more Energy Star® homes than any other state in the union—Phoenix alone accounts for over 20% of the national total. There are 51 Energy Star® certified builders in Arizona, and five have committed to building all of their homes to Energy Star® standards. The three largest of these builders who have made the 100% commitment are Beazer homes of Arizona, a Tempe-based builder which has built over 3,000 Energy Star® homes, Trend Homes of Phoenix, which has built over 1,300, and Hacienda Builders of Scottsdale, which has built over 1,000 (EPA 2002).

Several builders explained to SWEEP that the motivating factor is not energy codes, but rather the fact that they've figured out how to do the job right, and they want to deliver to their customers better homes with reasonable energy bills. Good homes means satisfied new homeowners and fewer expensive call backs. The fact that there's usually a third party inspector to verify that Energy Star® standards have been met helps, of course, as does good old fashion competition. When many Phoenix production builders are constructing tight, comfortable homes with monthly cooling bills of $40, builders must

[1] Energy Star® is a national, voluntary program that promotes energy-efficient products, including new homes. To earn the Energy Star® label, a home must be 30 percent more efficient in heating, cooling, and hot water use than a comparable home built to the Model Energy Code (MEC), or 15 percent more efficient than a comparable home built to a state code, whichever is more stringent. Performance is assessed by a certified third-party rater who uses blower doors, duct blasters, and other instruments to verify that new dwellings meet or exceed 86 on the scale used by the Home Energy Rating System (HERS).

compete by producing energy efficient homes, or lose business. It's clear from advertising brochures and buying patterns that consumers are becoming wiser and have grown to expect new homes on the market to be energy efficient.

To be sure, up-to-date energy codes will help substantially in improving the products of those builders not constructing Energy Star® homes, but the rapid pace of Energy Star® market acceptance shows promise of playing a key role for years to come.

New HVAC Installs: Doing it Right in Arizona

Jim Colgan is Vice President for Sales and Engineering for Chas Roberts, one of the largest residential HVAC companies in the US. They complete almost 32,000 new residential installs per year, about 120 per working day. Their crews do about 75% of all new residential jobs in Phoenix and close to half in Tucson, the largest markets in Arizona. Colgan and many of Chas Roberts' designers and field crews have attended training sessions offered by John Tooley of Advanced Energy—and the way they approach HVAC installations these days reflects the findings of recent building science.

SWEEP asked Colgan about key differences between what the company is doing now and what they were doing a few years back. Here are the main points of his response:

- Careful attention is paid to overall duct design. Designers use modern software (Wright J) to do a room-by-room load analysis to choose proper flows, duct sizes, and specify the appropriate air handler for the job.
- Duct sizes and air filters are both much larger to keep velocities and static pressures down. This results in a flow of about 400 cfm/ton across the air conditioning coil—the optimal rate for most residential coils—so units are more efficient at transferring energy to the conditioned space and fan motors have lighter loads.
- Air sealing of ducts is done carefully with attention to detail. The result is that installers routinely achieve less than 6% of nominal flow duct loss for Energy Star® houses and 3% of nominal flow for "engineered for life" super-efficient houses. (These flows are measured at 25 pascals with a duct blaster.)
- Flex duct rated at R-4 are used for most production homes, but R-6 ducts are used for engineering for life homes, about 10% of Chas Roberts' production.
- Every house has pressure relief for critical rooms, with master bedrooms at the front of the list. In the case of engineered for life homes, pressures are balanced throughout the home so that no area is pressurized at over 3 pascals even with the doors closed. This enhances overall system efficiency of the HVAC system, improves comfort and safety, and extends the lifetime of the home itself. Chas Roberts uses any of three strategies to achieve balance: add an extra return in such critical spaces as master bedrooms; add transfer grills above the door of critical spaces; or add "jump ducts" between a critical space and an adjacent hallway where there is unimpeded flow to the return duct, regardless of patterns of door openings. Jump ducts are short lengths of 12 to 20 inch diameter flex that "jump" into the attic then back down again. Grills used with jump ducts range from 14 x 14 inches to 20 x 30 inches, "whatever it takes" to ensure pressure differences are safe (less than 3 pascals in the case of EFL houses). Of course the particularly tight engineered for life dwellings require larger cross section grills and ducts to achieve pressure balance. Jump ducts are more effective at ensuring privacy than are transfer grills, which transfer sound efficiently as well as air.
- Care is taken to ensure that compressors have the correct refrigerant charge. (Studies in many cooling-dominated climates show that well over half do not.)
- The home is equipped with a high-quality digital thermostat.

Why does Chas Roberts do it since there are no energy codes? “In addition to market forces, it’s the right thing to do--it makes houses work better. We have fewer customer complaints and fewer warrantee calls,” says Colgan. “There’s nothing better than a happy homeowner.” (Colgan 2002).

Clearly, energy efficient HVAC systems are positively correlated to both happy homeowners and Chas Roberts’ business growth.

Both the electric and the gas utility companies in the Tucson area sponsor programs that provide incentives to builders to build homes that are 30% better than the Model Energy Code. Carl Rald, Energy Programs Coordinator for the City of Tucson’s Operations and Energy Office tells SWEEP that the homes are not only constructed better, they also have two important qualities that make them stand above both conventional “just meet” code homes or Energy Star® homes: they are all required to have controlled mechanical ventilation, and *every* home is thoroughly tested by well-trained technicians provided by the utility companies, as described in the sidebar below (Rald 2002).

Tucson Utilities’ Efficiency Programs for New Homes

(Note: this is an abbreviated version of a case study on Tucson Utilities’ efficiency programs for new homes; the full version is available on SWEEP’s web site, www.swenergy.org.)

Tucson grew 20% in population and 24% in area from 1990-2000; the metropolitan area (Pima County) has a population of about 900,000. In recent years, Pima County has averaged about 10,000 new residential building permits per year, with single-family residential structures being added at the rate of almost 500 per month (Tucson Planning Department 2001).

With this many new homes coming on line, a healthy competition has developed between the electric and gas utilities serving the Tucson metropolitan area, resulting in a number of comfortable, healthy homes whose energy use is quite moderate. Both utilities conduct programs that promote energy-efficient new construction—and work closely with builders to make it happen.

<u>Tucson Electric Power Program</u>

The Tucson Electric Power (TEP) Guarantee Home program was designed to include the steps shown by building science research to be key in constructing homes that are healthy, safe, comfortable, durable, and affordable. TEP guarantees that its homes will cost less than some maximum amount to heat and cool for the year, expressed to customers in dollars per day. In practice this runs from $0.80 per day for 900 square foot homes built by Habitat for Humanity to $4.00 per day for 10,000 square foot mansions constructed by custom builders. More typical homes, like 1850 square foot structures constructed by production builders, are guaranteed to cost less than $1.60 per day for space conditioning (Figure 1).

Figure 1. *The advertisement for this new home guarantees that costs for heating and cooling energy will not exceed $1.33 per day. (Source: TEP)*

Behind the scenes, TEP's staff performs an analysis of builders' plans (using Manual J software), tweaking details until the new homes they represent show strong promise for coming in at 40 to 50% better than homes built to Tucson's 1995 model energy code (soon to be 2000 IECC). The utility works with 57 builders in the Tucson area that participate in the TEP Guarantee Program to ensure that homes are efficient, healthy, and comfortable. This includes properly-installed insulation, duct sealing (<3% of the conditioned floor area leakage expressed in cubic feet per minute of flow at 25 pascals), envelope sealing (<0.3 natural air changes per hour), correct sizing of HVAC equipment, pressure balancing (frequently requiring the installation of additional return air paths), and fresh air ventilation systems that slightly pressurize the tight envelopes. In addition to working on more conventional homes, TEP works with builders of homes that make use of such materials as straw bales and Rastra™ (an insulating and structural wall system made of 85% recycled Styrofoam and 15% Portland cement).

TEP offers participating builders incentives that can be used to help offset additional building costs or for advertising. The company conducts advertising for the builders that includes radio, TV, newspaper, bill stuffers, internet, a variety of quarterly publications, and on-site sales material. TEP also sponsors training for builders, subcontractors and new-home customers, primarily in the form of seminars conducted by John Tooley and his colleagues of the Advanced Energy Corporation.

Most important, TEP's staff undertakes quality control by conducting instrumented inspections of each home at three points in the construction process: framing and distribution system installed; insulation installed; and final. Duct blasters, blower doors, and manometers are employed to ensure that ducts and conditioned envelopes are well sealed and that new homes are pressure balanced.

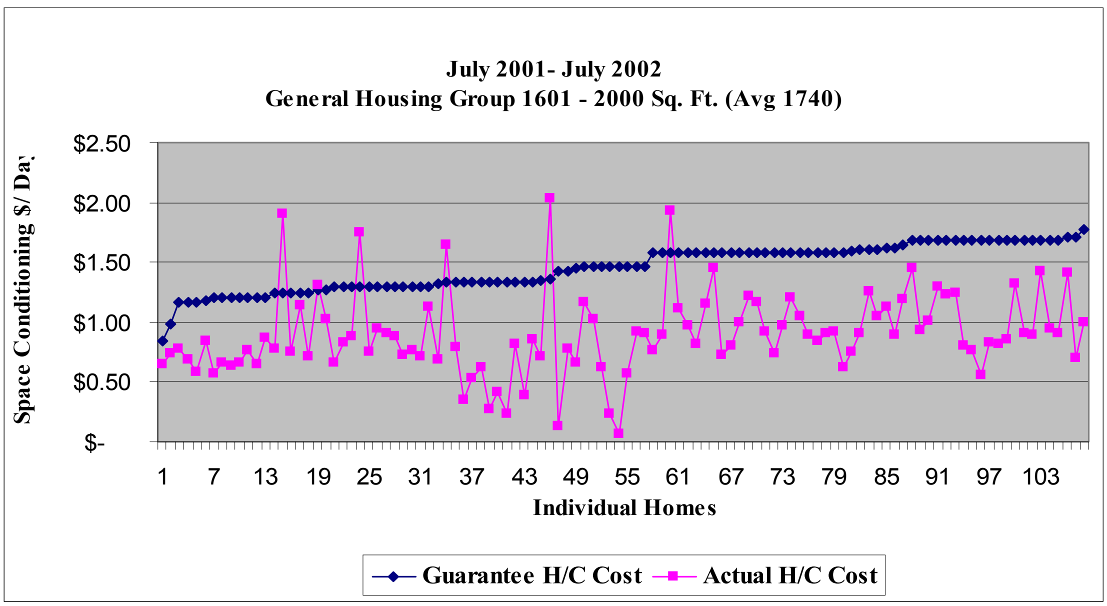
All of these services are offered at no cost to either the builder or the new home owner, but there's a *quid pro quo*. The new homes that participate in TEP's program must include heat pumps for space heating and employ electric hot water heaters. The company recommends (but does not require) 12 SEER heat pumps and encourages consideration of solar water heaters.

New homeowners who participate in TEP's program are rewarded with lower electric rates than non-participants for the life of the home. The three-tier rate is designed to provide an annualized 12%, 18% or 22% lower rate to the new homeowner and subsequent owners for the lifetime of the dwelling. All TEP Guarantee homes automatically receive the 12% option. If the homeowner agrees to time-of-use residential tariffs, the rates are lower still (the 18% option). Finally, if program participants elect time-of-use rates and agree to install solar or heat pump water heaters, their rates are the lowest offered by the utility to residential customers (the 22% option). According to Linda Douglas, TEP's Project Director, close to 60 percent of participants choose time-of-use rates, and in some projects, close to 100 percent install solar (Douglas 2002).

Every TEP Guarantee home meets or exceeds Energy Star® criteria because of requirements for fresh-air ventilation, insulation installed right, pressure management, and lower duct leakage standards. In addition, they employ a 100% inspection protocol rather than inspecting only a 15% sample of homes, the minimal requirement for production builders under EPA's Energy Star® program guidelines.

The period of guarantee is three years, and customers receive annual reports of total energy use and cost plus electric costs of space conditioning. (TEP calculates space conditioning costs by subtracting average energy used in shoulder months--when neither heating nor cooling is required--from months in which one or the other is used.) Once in a great while, a customer will also receive a credit on their energy bill, but if it's of much magnitude, TEP will re-inspect the home to identify and solve the problem (Figure 2).

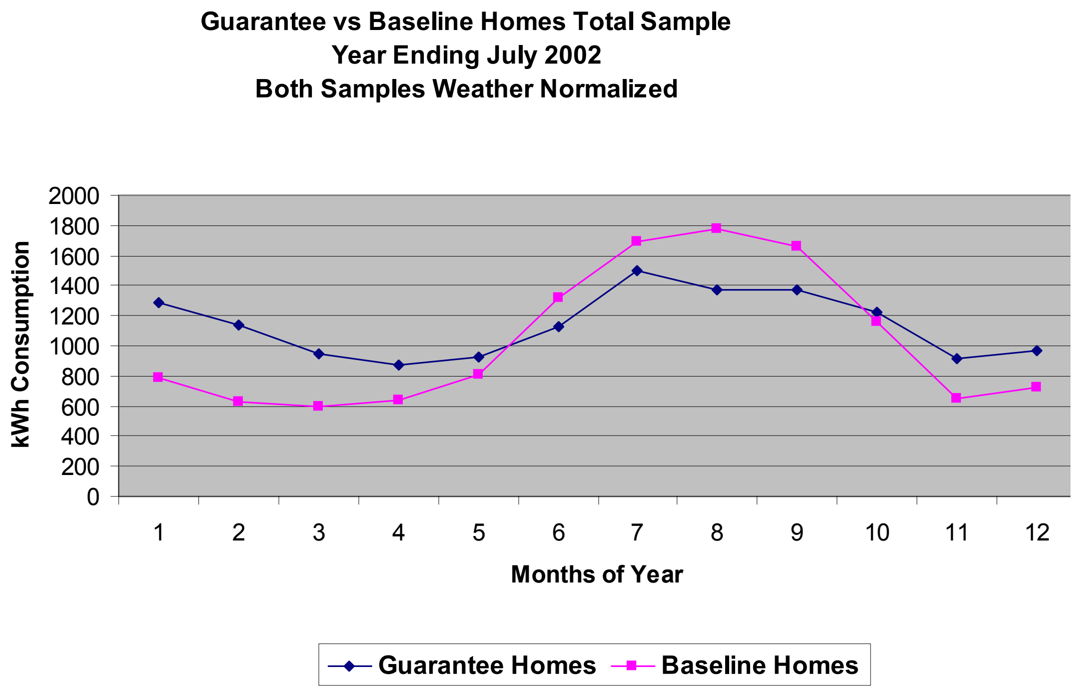
Figure 2. *TEP guaranteed maximum daily average costs for heating and cooling (total space conditioning) versus actual are shown in the figure below for 108 new homes between 1601 and 2000 square feet. Note that most actual costs are substantially below guaranteed, although about 5 percent are above. (Source: TEP)*



Builders are pleased with the program primarily because potential homeowner demand is high—the program helps sell homes. They also like the fact that the higher-quality homes they build minimize call backs, and if there are problems, TEP usually gets called before they do (Sandweiss 2002).

For its part, TEP is enthusiastic because the program renders a useful service for their customers that's clearly appreciated—comfortable homes and modest energy bills build loyalty and the process enhances TEP's branding. Further, the construction standards result in homes with a lower peak demand for energy, with is particularly important during the summer. This coupled with the increased number of heat pumps and electric water heaters on line during the wintertime plus time-of-use pricing helps to smooth the load profile—and enhance the utility's bottom line. Most funds for the program come out of the company's operating expenses so represent shareholder investments. In short, the program is a solid business venture for TEP (Figure 3). One of four new homes in Tucson is a TEP Guarantee program home; the company projects that 1800 homes will be built under the program in 2002.

Figure 3. *This shows the total electric energy consumption of homes that participated in the TEP program through 2002 and that of "baseline" homes—non-participating homes with conventional compressor-based air conditioning, as well as gas-fired hot water heaters and furnaces. Note that participant homes both diminish peaks in the summer and fill in valleys in the winter. The result is a much more attractive load profile from TEP's point of view. (Source: TEP)*



Southwest Gas Program

Southwest Gas (SG) conducts a new homes program in Tucson called Energy Advantage Plus. It was established shortly after the TEP Program in part to help the gas company compete for heating market share. Participating builders use natural gas appliances for both space and water heating. Although there are no guaranteed savings to the new homeowner, the Southwest Gas program, which uses HERS software, gives each home a HERS rating, and the homes that are in the top tier are Energy Star®- rated dwellings.

The SG program has three tiers. "Program Level 1" represents a target of a 15 % improvement over Tucson's modified 1995 MEC, providing builders with plan reviews and visual inspection of energy-relevant features of new homes. In the Home Energy Rating System (HERS) rating scheme, Level 1 homes rate at 83 to 84.5. SG pays an incentive of $125 per home, where the money is made available to participating builders to underwrite their advertising efforts on a 50% cost-share basis.

In response to builder interest, Energy Advantage Plus now has two additional tiers, HERS 85 and HERS 86 and beyond. This third tier qualifies dwellings as Energy Star® homes, and SG puts $150 into the cooperative advertising fund for each of these. For both of these higher level homes, SG uses a combination of visual inspections and instrumented testing on all models and on a sample of participating dwellings. For custom built homes, they sample at 100 % and for production-built homes, they sample at 15% or more, often exceeding Energy Star® requirements.

So far, 138 builders participate in the SG program, and almost 20,000 homes have been built or committed to its standards since the program's inception. According to Rita Ransom, Residential Marketing Specialist who has been with the Southwest Gas program from the start, as the program matures, first tier homes are becoming the exception and Energy Star® homes are becoming the rule. The utility estimates that in 2002 about 3500 dwellings will be constructed to Energy Advantage Plus guidelines in the Tucson area (Ransom 2002).

Southwest Gas hires nationally-known trainers like Mark LaLiberte to conduct seminars for groups of builders and also to work with individual builders in the field on a one-on-one basis. In addition, the company advertises the program in local print media as well as via bill stuffers, routinely including the names of all participating builders. Southwest Gas also provides a handful of advertising services for its builders, including multi-color brochures and information packets that would be expensive for builders to produce on their own.

Overall Results

Over 70 percent of the new single-family homes being constructed in Tucson are built under one or the other of these utility-sponsored programs, and as a direct result practical wisdom in achieving energy-efficient homes has become the rule among both the local and national builders operating in the Tucson area. Each utility spends in the neighborhood of one million dollars per year to run its program, and this fiscal commitment is increasing. In addition to defraying the costs of plan reviews and home inspections, this includes healthy budgets for training and advertising. This works out to be less than $500 per home.

The State of Arizona alone produces over 20% of the Energy Star®-rated homes in the US, well over 6,000 per year. A very substantial number are in Tucson, where SWEEP estimates that over 50% of the dwellings built in 2002 qualified as Energy Star® homes.

Another code development in Tucson stems from the work of an intentional community, Civano, which was formed in the 1970s in response to the first energy crisis. Working with the City of Tucson, the community has developed what it calls "IMPACT (Integrated Method of Performance and Tracking) Standards." According to Civano's web site, "the IMPACT Standards explore how it is possible, over time, to reach a balance between growth, affordability, and achieving a greater integration with our environment. The Standards address energy efficiency, resource and environmental awareness, and community-strengthening goals, and provide a means of measuring progress toward attaining them." Under IMPACT, all homes in the Civano community are built to use less than 50% of the energy of a dwelling designed to just meet MEC 95 standards.

Many homes in the Civano area have active solar hot water systems, but unhappily a number of the collectors have developed leaks (Rald 2002). "We're still in the finger pointing phase," Carl Rald reports, "but the problem seems to stem from a collector manufacturer in the Phoenix area." There doesn't appear to be widespread disenchantment with the solar energy as such, but the incident serves as a reminder of the importance of quality control in achieving good, long-term performance from energy efficiency and renewable energy measures.

COLORADO

Status of Energy Codes

Colorado is a home rule state, so local jurisdictions preside over the energy code adoption and implementation processes. At least ten large jurisdictions and a handful of smaller towns have adopted IECC 2000 residential energy codes and ASHRAE 90.1 1999 commercial codes. In addition, there is activity in at least six other cities and counties that show promise that up-to-date codes will be adopted soon. A number of other jurisdictions, including the City of Denver, have implemented the 1995 MEC as a residential energy code as well as some version of ASHRAE 90.1 for commercial buildings.

Table 1-2 describes the state of the code adoption process in the largest of Colorado's jurisdictions.

Table 1-2. *Current Code Adoption Status in Colorado, Fall 2002.*

County	City	Residential Energy Code	Commercial Energy Code
Adams		None	None
	Brighton	None	None
	Commerce City	Planning for IECC	Planning for IECC
	Thornton	2000 IECC	ASHRAE 90.1-99
	Westminster	2000 IECC	ASHRAE 90.1-99
Arapahoe		1995 MEC	ASHRAE 90.1-89
	Aurora	1989 MEC	ASHRAE 90.1-89
	Englewood	None	None
	Greenwood Village	2000 IECC	ASHRAE 90.1-99
Boulder		2003 IECC, Feb 03	ASHRAE 90.1-99
	Boulder	2000 IECC	ASHRAE 90.1-99
	Longmont	1998 IECC	Colorado Energy Guidelines (ASHRAE 90.1-89)
	Louisville	1995 MEC	ASHRAE 90.1-89
Broomfield	Broomfield	1995 MEC	MEC 95 (97 UBC)
Denver	Denver	1995 MEC	ASHRAE 90.1-89
Douglas		Local Code	None
	Parker	2000 IECC	ASHRAE 90.1-99
	Castle Rock	1995 MEC	ASHRAE 90.1-89
El Paso		2000 IECC	ASHRAE 90.1-99
	Colorado Springs	Planning for IECC	
Fremont		Planning for IECC	Planning for IECC
Garfield	Glenwood Springs	2000 IECC	
Jefferson		2000 IECC	ASHRAE 90.1-99
	Arvada	1995 MEC	ASHRAE 90.1-89
	Golden	None	None
	Lakewood	1986 MEC	1986 MEC
Larimer		None	Colorado Energy Guidelines (ASHRAE 90.1-89)
	Fort Collins	1995 MEC (amended) Planning for IECC	ASHRAE 90.1-89
Mesa	City of Grand Junction	1998 IECC	ASHRAE 90.1-89
Montezuma		2000 IECC	2000 IECC
Morgan		Planning for IECC	Planning for IECC
Pitkin	Aspen	Planning for IECC	Planning for IECC
Pueblo	Pueblo	None	None
Summit		Planning for IECC	Planning for IECC
	Frisco	2000 IECC	2000 IECC
Weld		Planning for IECC	Planning for IECC

The municipal utility in Fort Collins is in the process of adopting goals of 15% peak demand reduction and 10% electricity savings per customer over a ten-year period. If implemented, the goals will support a number of energy efficiency measures, among them the provision of training and technical assistance tailored to both code inspectors and builders active in Fort Collins. This, in combination with the more stringent IECC 2000 newly on the books, should result in new buildings with better energy performance.

Colorado Springs Utilities is the largest municipal utility in Colorado. MEC 95 is on the books in Colorado Springs, but it is not well enforced. There is little movement toward upgrading the energy code in the City, but SWEEP has begun to work with the utility's staff to promote their playing a more active role in energy efficiency in general and promoting the adoption and enforcement of modern energy codes in particular. There is strong interest in developing energy efficiency programs on the part of the staff. We also anticipate meeting with Colorado Springs Utilities' senior management to strategize specifically on the issue of adopting and enforcing modern energy codes.

There are a number of barriers to new code development in Denver and activity has temporarily ground to a halt. Some relate to perceptions on the part of trade unions that IECC 2000 codes would force changes in procedures that would entail job loss.

Denver has municipal elections coming up in May of 2003 that will result in the turn over of the mayor and large percentage of the City Council. (Most elected office holders in Denver will not be running due to term limits.) Accordingly, in concert with several other organizations, SWEEP is examining practical options toward helping energy code adoption becoming a priority item with the City's new leaders. Toward that end, SWEEP has made presentations to members of Colorado's Sierra Club interested in energy efficiency, and we anticipate meeting with several mayoral candidates well before municipal elections to urge their support of progressive energy policies.

The City of Boulder has adopted IECC 2000 codes, but with an interesting twist reflective of the community's interest in sustainability and being as "green" as possible. See sidebar below.

Residential Energy Efficiency in Boulder, CO

The Boulder City Council passed the Kyoto Protocol goals for the city in 2002, and is studying a wide variety of measures to meet these goals. The building permitting process reflects these priorities. The city has had a green points program for residential construction for five years, so when officials decided to implement the 2000 IECC, they elected to combine key features of the green points program with the new code. According to Cory Schmidt, Chief Building Official, all building permits for new homes and additions are required to attain a minimum number of "green points" on a sliding scale that varies directly with the size of the dwelling (Schmidt 2002). Accordingly, a new home of up to 1500 square feet must attain 50 points, where one of 3,000 square feet must attain 75 points. Remodeling jobs are also required to attain a minimal number of green points, again depending on the extent of the job.

Before any other points can be earned, points reflective of the current IECC must be integrated into the green points building permit process as illustrated in the table below:

Number of Green Points Awarded for IECC Values

Category	IECC Values	Green Points
Glass U-Value	0.50	0
	0.45	2
	0.40	4
	0.35	6
	0.30	8
Wall Insulation	R-11	0
	R-13	1
	R-15	2
	R-19	3
	R-24	4
Ceiling Insulation	R-30	0
	R-34	1
	R-38	2
	R-42	3
Floor Insulation	R-15	0
	R-19	1
	R-24	2
Basement Insulation	R-10	0
	R-13	1
	R-19	2
	R-24	3
Slab Insulation	R-5	0
	R-7	1
	R-10	2
Crawl Insulation	R-15	0
	R-19	1
	R-24	2
Heating Equipment	78%	0
	84%	2
	90%	4
	94%	6
Air Conditioning	11 SEER	0
	12 SEER	1
	13 SEER	2
	14 SEER	4

In addition to these measures, green points may also be accumulated by:

- The use of recycled materials;
- Simplicity of design to minimize land use;
- Water conservation and xeriscape landscaping;
- Energy efficient plumbing (demand water heater; device for saving hot water);
- Hard-wired CFL lighting;
- Energy-efficient appliances;
- Natural cooling measures;
- Extra HVAC measures (e.g., heat recovery ventilation, hydronic heating, radiant slab, whole house fan);
- Solar (hot water and both active and passive space heating);
- Air quality measures (e.g., closed combustion heating appliances; HEPA filter, low VOC paints, infrastructure to support alternative fuel vehicle); and

- Other innovative approaches (products or designs that help exceed IECC and Green points program overall building performance).

In practice, plans must be submitted along with the results of a MECcheck computer printout and a Green Points form. These are reviewed before a building permit is issued. Compliance with some of the items are self reported by the builder, but City inspectors check most items two to three times during the construction process.

Doug Parker, a Boulder-area builder who specializes in solar additions and major retrofits, finds the energy-efficiency elements of Boulder's code to be reasonable. "After I get my architect up to speed in running MECcheck, it's usually a piece of cake to get the Green Points I need for plan approval." (Parker 2002). Parker routinely does careful air sealing, super insulation, high-quality window replacement, and upgrades the heating system in his retrofits. When major retrofits entail work on more than half of the home, the Boulder code stipulates that the whole house must be brought up to code. That's usually practical, but once in a while, it would be outlandishly expensive and virtually impossible to do. Fortunately, a modification to Boulder's code implemented in October 2002 allows a variance when, for example, gaining access to existing attics would entail major surgery, since such would be inconsistent with the "reuse and recycle" spirit of the Green Points program.

Cory Schmidt reports that the first year of implementation was difficult for both the City's staff and local builders, but with experience and a handful of practical modifications, things are going more smoothly as of the winter of 2003-2003. Nonetheless, plans are afoot to do more training for both builders and the City's code enforcement staff.

Other Efficiency Work

The Energy Star® program in Colorado is active and is accelerating its pace. There were 486 Energy Star® labeled homes built in CO the last 12 months, 73% of the total of 662 labeled in the state since the program's inception (EPA 2002). The two most productive Energy Star® builders in the past 12 months were Engle (236), which became an Energy Star® builder in 2002, and Lifestyle Homes (101). Lifestyle Homes, McStain Neighborhoods, Sopris Development, and Habitat for Humanity of Denver have all committed to building 100 % of their homes to the Energy Star® standard.

E-Star™ Colorado[2] conducts an annual New Millennium Energy Star® Builder Awards program through which innovative Energy Star® builders may compete in several categories (region of operation, builder type, etc.). SWEEP participated in selecting builders for this year's awards and witnessed the diversity and creativity of design illustrated by the energy- efficient buildings submitted for awards. The award process, which aims at promoting good buildings, good builders, and the Energy Star® program itself, seems successful on all counts. Award winning builders are quick to include the fact in their promotional materials.

[2] E-Star™ is the name of the home rating program operated by Energy Rated Homes of Colorado. Headquartered in Denver, their web address is www.e-star.com.

The history of code development has resulted in but few in-field evaluations of actual before-and-after code building quality and energy use. An instructive exception was recently undertaken in Fort Collins, which implemented a modified version of the 1995 MEC in 1996. Toward assessing the energy-related consequences of the code, the progressive municipal utility that serves the area co-sponsored a study of new single-family homes built between 1994 and 1999. The analysis indicated an average annual savings of 175 therms, about half the savings predicted to result from code-driven improvements. The assessment also included instrumented field inspections of 20 homes in construction and 40 that were recently completed. The inspections revealed a pattern of leaky duct work, oversized HVAC equipment, and poor-quality air sealing that together account for the disappointing savings.

"Now that we know what the problems are, we can seek solutions," observes Doug Swartz, an official of Fort Collins Utilities and principal author of the evaluation report (Swartz 2002). Working to provide feedback and training to builders heads the list.

Behind the Drywall: Problems and Opportunities in New Fort Collins' Homes

The City of Fort Collins produced a useful brochure with the above title that draws inferences from the study of new homes and gives practical counsel to both builders and potential homeowners. Here are some highlights:

Problems:
Minimums versus optimums: Energy codes set minimum requirements rather than defining the best way to build a house. However, code requirements often became standard building practices; there were few attempts to exceed codes. Nonetheless, code violations were commonplace, with oversized and poorly-installed air conditioning equipment and leaky ducts being the most frequent offenders.

Low constructions standards: Construction standards varied widely. For work "behind the drywall," standards sometimes appeared low, suggesting speed often took priority over quality.

Lost opportunities: Many problems could have been avoided easily and at moderate cost on the front end, but solutions are prohibitively expensive in completed homes.

Solutions:
"Whole house" approach: Use it in both design and construction to produce homes that deliver what buyers expect: comfort, health and safety, durability, and low energy bills.

Sun-conscious design: Take advantage of daylighting and wintertime heating benefits while reducing unwanted summer solar gains. Pay close attention to orientation of the home and placement, sizing, and shading of windows. Select low-solar-heat-gain windows where needed to avoid too much solar heat.

Quality shell: Build a tight, well-insulated shell to improve comfort and reduce heating and cooling needs. Specify high-performance windows.

Indoor air quality: Build a tight house so that ventilation can be controlled and pollutant paths sealed. Use materials that produce few pollutants. Specify sealed-combustion gas equipment.

Heating and cooling systems: Size the equipment and distribution system appropriately. With forced air ductwork, consider a simpler duct system, make the ducts permanently airtight, and provide a way to balance air flow to different rooms.

Quality control: Establish procedures to ensure that components have been installed, that they meet construction standards, and that they work as part of the whole house system.

NEVADA

The population of the Las Vegas metropolitan area has doubled to 1.5 million since 1990, and Clark County adds about 7,000 new citizens each month. Percentage wise, this makes Las Vegas the fastest growing metropolitan area in the U.S., a fact that is reflected in the over two thousand new single-family housing starts per month and rapidly increasing electric use.

Nevada has a mandatory state-wide energy code consisting of modified versions of the 1986 MEC for both new residential and commercial buildings. State-owned facilities must comply with the 1989 version of ASHRAE 90.1. In addition, many local jurisdictions, including most where substantial numbers of new homes are being built, have adopted more recent versions of the MEC. The 1992 version of MEC has been adopted in the greater Las Vegas area. The 1995 version of MEC is in place in Northern Nevada, including the City of Reno and Lyons County.

Table 1-3. *Present energy code adoption in Nevada.*

Jurisdiction/Area	Residential Code	Commercial Code
State Buildings		ASHRAE 90.1 1989
Clark County	MEC 1992	MEC 1986
Las Vegas	MEC 1992	MEC 1986
North Las Vegas	MEC 1992	MEC 1986
Henderson	MEC 1992	MEC 1986
Mesquite	MEC 1992	MEC 1986
Boulder City	MEC 1995	MEC 1986
Reno	MEC 1995	MEC 1986
Lyons County	MEC 1995	MEC 1986
Balance of State	MEC 1986	MEC 1986

According to Dave McNeil, Administrator of the Nevada Energy Office, only the state legislature can authorize changes in state-wide building codes, and the last time they authorized changes was in 1985 (McNeil 2002). In 1995, an attempt was made to secure state legislation to authorize up-to-date building codes, but the legislation died in committee. Local jurisdictions may adopt energy codes, but apart from those noted above, there is no activity toward adopting up-to-date codes. There are no commercial energy codes in the state, save for state-owned facilities where plans are checked for an engineer's stamp that the building is consistent with ASHRAE 90.1, but enforcement is not undertaken.

The Energy Office does promote awareness of IECC codes and undertakes to stimulate more energy efficient building practices generally. Toward understanding the degree to which as-built homes meet or exceed current codes, the Energy Office has contracted for a study of 200 homes in the Las Vegas and Reno areas, where most new homes are being constructed. Both testing and an analysis of actual consumption as reflected in billing data are included in the analysis. A draft of the report by a consulting group headed by the Britt/Makela Group is expected early in 2003 (Makela 2002). The aim is to use the results to provide more technical and educational services to both building officials and to builders. Toward that end, the Energy Office has hired John Tooley of Advanced Energy to work with builders in Northern Nevada in February 2003.

Other Efficiency Work

Energy Rated Homes of Nevada and the Building America Program are active in Nevada, both of which are supported by the Nevada State Office of Energy. Only a few large builders in the Las Vegas area were involved in the Energy Star® program until a big push was made to add others in mid-2002 when Building America became co-branded with Energy Star®. This very public process resulted in features on various builders and building inspectors in the local newspapers—and a healthy competition ensued. As a result, there are now 31 builders that are official Energy Star® partners, a third of which are now producing only Energy Star® homes. Importantly, those who have committed to producing only Energy Star® homes tend to be large production builders. In the last 12 months, they have produced 86 percent of the Energy Star® homes in Nevada.

As an illustration of the recent rapid growth of the Energy Star® program, in the history of the Energy Star® labeling process, 6989 homes have been labeled in Nevada. Of these, 4142, or 59 percent, have been labeled in the past 12 months (EPA 2002). One knowledgeable representative from Energy Rated Homes of America estimates that the market share for Energy Star® homes in the Las Vegas metro area was around 25% in 2002, up from about 10% in 2001 (Collins 2002).

This growth in Energy Star® homes has been matched in part by growth in inspection companies. There are seven rating companies active in Nevada that between them have rated over 11,000 homes. Builders' Choice is a Las Vegas-based rating company that has accomplished more than 4000 ratings for both the Engineered for Life and the Energy Star Homes Programs over the last five years. Jill Gilmore, President of Builders' Choice, explains that five years ago only 3% of new buildings were rated, two year ago it was 15 to 17%, and now it's 30 to 35%. At present, they have six raters on staff, most of whom were trained by Advanced Energy to become certified HERS raters (Gilmore 2002).

In practice, raters go into a home twice. The first visit is at rough just after the duct work and air handling unit are installed. Duct blaster tests are performed (with separate supply and return measurements) to verify that leakage is below 5%. If further sealing is needed the ducts are still easily accessible at this stage in construction. A blower door test is performed at the final test. The target maximum for certification is 1 cfm per square foot at 50 Pascals pressure on the home.

Builders, which pay $300 or more for the service, are becoming proactive in ensuring their HVAC, insulating, and air sealing subcontractors are doing a good job. An indication that the services supplied by Builders' Choice are appreciated is that they routinely test 1 of every 4 homes constructed by production builders instead of the 1 of 7 required by Energy Star®.

Some builders, like Pulte, are building energy efficient homes that meet the Engineered for Life platinum standard. An important detail of these homes involves defining the conditioned envelope at the roof deck instead of the attic floor. See sidebar below.

The Unvented Attic Approach

The Engineered for Life homes are very tight, well-insulated structures with high-quality fenestration. They have air handler/furnaces and duct work in the attic, but unlike conventional construction with insulation at the attic floor, the thermal envelope includes the attic. This is achieved by installing a "cocoon" of insulation just under the roof deck. In practice a mesh is stapled to the underside of the 24-inch-on-center attic trusses which extends down to the sidewalls. Cellulose is blown into each bay by inserting a tube into a temporary slit made in the mesh toward the top of the ceiling and fishing it down toward the perimeter walls. This facilitates blowing insulation tightly against the roof deck and ensuring that there are no voids. The result is attic temperatures that are much lower than is usually the case in Las Vegas homes during the cooling season, with the consequence that the air handler and ducts are subject to lower losses. Although still in the conditioned envelope, the ductwork is carefully sealed as are recessed lighting fixtures.

Lower losses in the thermal envelope coupled with higher system efficiency of the HVAC system enables downsizing the furnace and chiller. According to Paul Hughett, President of Silverado Mechanical and partner in Sierra Air Conditioning, a 2,000 square foot Engineered for Life home requires a 75,000 Btu/hour furnace and a 3.5 ton air conditioner rather than the 100,000 Btu/hour furnace and 5 ton air conditioning unit more typical of conventional new homes of the same size in the Las Vegas area. Closed combustion condensing furnaces rated at >90% steady state efficiency and SEER 12 A/C units are routinely installed. Hughett's companies are doing 4,000 to 5,000 installs per year. "The whole system cost is very little more than the way we used to do things with the air handler and ducts in hot attics," Hughett explained (Hughett 2002).

NEW MEXICO

The 1992 MEC (with state amendments) is the mandatory minimum energy efficiency requirement for all new homes built in New Mexico, but implementation is spotty in most areas. An exception is the fast-growing Albuquerque area, where the building permitting and inspection process is rigorous. State wide, new homes are going in at the rate of about 700 per month, over half of which are in the vicinity of Albuquerque.

All new state-owned commercial buildings must comply with ASHRAE Standard 90.1-1989. All other new commercial buildings must only comply with older codes, ASHRAE 90A-1980 and 90B-1975.

In some cases, local jurisdictions do not have staff qualified to enforce the code, so the State's Construction Industries Division undertakes both plan reviews and inspections. The Construction Industries Division relies on the Energy Conservation and Management Division of the Energy, Minerals and Natural Resources Department for technical assistance.

A working group under the leadership of Harold Trujillo of the Energy Conservation and Management Division has been meeting for a year and a half to develop a version of IECC 2000 code suitable for New Mexico. A final decision to adopt the code was made in December 2002 with implementation slated for May of 2003.

At present, state amendments to the IECC code will likely include a provision to allow lighting densities of up to 2 watts per square foot in commercial buildings and another to accommodate log homes based on an "effective" U value that reflects an annual analysis that includes the effects of solar gain.

Other Efficiency Work

There are seven Energy Star® builders in New Mexico, one of which, Artistic Homes in Albuquerque, builds only Energy Star® homes. Artistic has constructed 525 Energy Star®-labeled homes, 72 percent of which have been built in the past 12 months.

UTAH

Effective January 1, 2002, Utah implemented a mandatory statewide IECC 2000 code for all new residential and commercial buildings. Utah's state energy office is pleased to have a state-of-the-art energy code in place, but implementation of the code is largely a local matter. Most cities ask builders of residential structures to submit a MECcheck analysis with their plans as part of the building permit process. COMcheck is required by most jurisdictions for small commercial buildings.[3]

David Wilson leads the Utah Energy Conservation Coalition, Inc., a non-profit organization hired by the Utah Energy Office to train code officials and builders in attaining code compliance and building energy efficient structures. Much of the Coalition's work is in the field, where instruments like duct blasters and blower doors are employed to both test structures and demonstrate to builders areas that need more attention. The Coalition has found that around 50% of new homes tested are not in compliance with the new code (Wilson 2002). Hopefully this situation will improve over time through training and the growing awareness of energy efficient building techniques. Plans are afoot to extend the Coalition's work into the commercial buildings sector.

Utah is strongly committed to energy efficiency in state-owned buildings. All new state buildings are being designed to use at least 25% less energy that required by the ASHRAE 90.1-99 model code. According to Mike Glenn of the Utah Energy Office, this "raising the bar" on commercial building codes for state buildings is one of several steps recently taken to increase the energy efficiency of state buildings. The ultimate aim is to adopt Silver LEED[4] as the standard for state buildings (Glenn 2002). Utah's program for new state buildings includes design assistance and incentive payments to building designers based on the level of energy efficiency achieved. Also, the program strives to achieve energy savings without increasing first cost through an integrated design approach. It is estimated that seven new buildings constructed during 1996-98 achieved 22-50 percent energy cost savings (relative to buildings that just comply with the ASHRAE 90-1-1999 standard) as a result of the program (Case and Wingerden 1998).

An area of particular emphasis has been ensuring that both new and retrofit school buildings in Utah are energy efficient. In practice, Jerry Zinger of the University of Utah Experimental Station works with architects and reviews school designs for code compliance. In addition, inspections are made to check that the bricks and mortar in new or retrofit schools match the energy efficiency of the buildings depicted by approved drawings.

Concerning privately owned commercial buildings, there is a *de facto* distinction between large buildings and smaller ones. If a professional engineer does the drafting, code

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[3] MECcheck and COMcheck are building code compliance software tools sponsored by the U.S. Department of Energy. They may be downloaded from DOE's codes and standards website, www.energycodes.gov.

[4] LEED is the U.S. Green Building Council's rating system for Energy Leadership in Energy & Environmental Design. It assigns points for design elements that contribute to achieving energy-efficient buildings. Silver LEED ratings usually result in efficiency levels that exceed ASHRAE 90.1-1999 standards by 35 to 50- percent. Information on the LEED™ Green Building Rating System is available from www.usgbc.org/LEED/leed_main.asp.

officials routinely accept his PE stamp for meeting code. Small commercial buildings like fast food chains and quick oil change shops are asked to run COMcheck software and submit the results with their plans.

Other Efficiency Work

There are 16 Energy Star® builders in Utah, one of which has built over 700 Energy Star® homes, far and away the greatest number in the state. Ence Homes, out of St. George, operates in both southern Utah and Nevada, and builds about 200 homes each year. Ence builds only Energy Star® homes and advertises the fact heavily in their sales literature and other media.[5] They have won two major awards from the EPA in the past three years, most recently the Energy Star® Builder of the Year award. In the fall of 2002, Ence broke ground on a group of houses slated to meet the requirements for the Engineered for Life Platinum standard. This is Ence's first set of houses in which they have insulated at the attic ceiling instead of its floor, thus allowing for the HVAC system to be enclosed in the thermal envelope (Ence 2002).

WYOMING

The Wyoming State Fire Marshal's office develops minimum building codes and standards for the state. The 1997 Uniform Building Code (UBC) is the current statewide code, and while it references the 1995 Model Energy Code (MEC) in an appendix, the Fire Marshal's office has yet to officially adopt the appendix, and thus the code is not in effect.

There were a total of 1,392 housing starts in Wyoming in 2000, the most recent year for which statistics are available. Although the number of housing starts seems to be increasing, there are no national builders currently operating in Wyoming, nor is the Energy Star® Program active in the state. The state energy office reports that they have no indication that energy-efficient buildings are being constructed in the state. The combination of very weak energy codes and low energy prices results in quite high energy use per household.

Up until recently, there has been little activity toward developing up-to-date energy codes in Wyoming. However, in 2001, Wyoming's state legislature formed an energy commission aimed at developing a cogent energy policy. The 15-member Wyoming Energy Commission (WEC) is composed of six state legislators and nine private sector

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[5] While on hold, the caller to Ence hears the following: "Ence is modern and forward thinking! EPA has recognized only one home builder in the nation to get a nationwide award from EPA, Ence Homes. We walked onto the stage to receive a beautiful crystal award. But what's this mean for you? Reduced utility bills, increased comfort, and possibly preferred financing ratings (because of lowered energy bills) for your Ence home."

members that represent energy and related interests, and is staffed by the State Energy Program and Natural Resources Program. The WEC has met for over a year and has produced draft energy plan chapters on the following topics:

- Conservation and Efficiency
- Energy Resources - Fuels Policy
- Transportation
- State Energy Taxes and Revenues
- Environmental Impacts
- Community Impacts

The process involves substantial public comment and its work is available on a website developed for the purpose, www.wyomingenergy.org.

SWEEP offered substantial input into the chapter on Wyoming's conservation and efficiency policy, including urging the state to develop and enforce recent versions of the IECC for residential and commercial structures. In response to the comments of SWEEP and other, the document is currently under revision and was the subject of a hearing in Cheyenne on December 20.

According to the principal author of the chapter on conservation and energy efficiency, Lisa Lindemann of Wyoming's Natural Resources Program, the policy under consideration would direct the fire marshal to adopt and implement a recent energy efficiency code, such as the IECC 2000, and apply that code to all state buildings on or before July 1, 2004 (Lindemann 2002). The policy will also recommend that local jurisdictions add recent versions of the model energy code to cover both residential and commercial privately-owned new buildings. The state plans to supply training for builders and building code officials as well as provide co-funding for code compliance and enforcement activities. The policy includes seeking funding from the Department of Energy to help defray costs for training and enforcement activities.

SECTION 2

ANALYSIS OF OPTIONS

Buildings that are not energy efficient tend to be uncomfortable—with cold, drafty areas in the winter and overheated areas in the summer—wasteful, and expensive to operate and maintain. It is possible to build efficient buildings (whose initial costs are little if any more than inefficient ones) which are more comfortable, less expensive to operate and maintain, and less vulnerable to such contingencies as extremes in weather or power outages. In this section, we estimate the energy and economic savings that would result in each state from two levels of efficiency improvement: (1) bringing all new homes into compliance with the 2000 IECC; and (2) bringing all new homes to superior level of energy performance represented by exceeding Energy Star® levels.

Analytical Approach

We begin by envisioning buildings whose energy-relevant features and overall performance is "representative" of the base stock presently being built in a state under current levels of energy codes and their enforcement. We then envision similar buildings that are built to a modern energy code, typically IECC 2000 for residential and ASHRAE 99.1- 1999 for commercial. Finally, we examine a home built to Energy Star® standards that is also optimized for orientation. We have chosen this approach both because it illustrates energy efficiency options and because it reflects the diversity of new housing stock in the Southwest. Of course, in areas where there are codes, sometimes codes aren't enforced or actual performance is less than might be predicted by the code. On the other hand, there are homes that not only meet but out perform code homes by a good deal.

Energy performance and cost data are then compared along with lifetime costs. Finally, energy and cost savings are examined for each state under scenarios of growth that are from best available sources.

Energy-10, Version 5 software is used to model residential buildings in Phoenix, Denver, Las Vegas, Albuquerque, Salt Lake City, and Cheyenne. An hourly simulation program developed by Doug Balcomb at NREL and a number of consultants, the software is technically sound and produces a variety of useful graphic outputs.

Table 2-1 shows the characteristics of three residential structures whose non-energy-related elements are identical and whose energy-related elements reflect a typical (base) building, an IECC 2000 building, and an Energy Star® building respecting orientation.

Table 2-1. *Residential Building Description*

Building Element	Base	IECC 2000	Energy Star+
Floor Area ft^2	2100	2100	2100
Volume ft^3	16,200	16,200	16,200
Wall R value	12.6	12.6	19.2
Attic R value	19	29	38
Window U factor	0.78	0.47	0.31
Window shading?	No	No	Yes
Window area ft^2	228	384	384
Number of windows	16	16	16
Orientation (N/E/S/W)	5/3/5/3	5/3/5/3	3/1/11/1
HVAC system	DX cooling w/ gas furnace	DX cooling w/ gas furnace	DX cooling w/ gas furnace
Efficiency	80%, EER = 8.9	80%, EER = 10	90%, EER = 13.0
Heating Thermostat	70F, no setback	70F, no setback	70F, setback to 65F
Cooling Thermostat	78F, no setup	78F, no setup	78F, setup to 83F
Envelope infiltration, in^2	ELA = 400	ELA = 215.5	ELA = 58..3
Duct leakage, total %	45	11	3
Lighting	Incandescent	Incandescent	CFLs and Daylighting

Table 2-2 shows projected annual energy use of the three houses in the six cities selected from the Southwest states. Overall site energy use is in millions of Btu's, electricity in kWh, and gas in therms. Savings from the base home are indicated in both energy and cost figures. Note that in the example chosen, in all cases it is actually slightly less expensive to construct more energy efficient structures. In subsequent analyses to be undertaken in the next version of this report, a base case house that is somewhat less expensive will be chosen for analysis.

The most significant finding of this analysis is the substantial savings achievable by the Energy Star® + homes. This is principally to do with orientation and overhangs, but also to a substantial degree on further sealing of both the envelope and the ducts beyond the IECC and Base homes. Other improvements in the Energy Star® + homes stem from multi set back thermostats, daylighting controls and compact florescent fixtures.

Life cycle cost savings are computed assuming a lifetime of 30 years and a discount factor of 5%. The average life cycle savings of the IECC code to base home over the region is $13,907. The average life cycle savings of the Energy Star® home to base is $32,191. Of course, well built, energy efficient homes may be expected to have a lifetime of up to three times the assumed 30 years, so this analysis is conservative.

Table 2.2. *Projected Savings.*

	PHOENIX			DENVER			LAS VEGAS		
	Base	IECC 2000	En Star +	Base	IECC 2000	En Star +	Base	IECC 2000	En Star +
Annual energy use, MBtu	182.5	156.7	83.5	283.9	180.7	71.3	188.4	151.9	78.9
Annual energy savings over base, Mbtu		25.8	99		103.2	212.6		36.5	109.5
Annual electric use, kWh	41,723	38,289	18,450	23,651	24,119	13,436	36,396	34,403	17,095
Annual electric savings over base, kWh		3,434	23,273		-468	10,215		1,993	19,301
Annual gas use, therms	401	260	205	2032	985	254	642	345	205
Annual gas savings over base, therms		141	196		1047	1778		297	437
Annual energy cost, $	3,765	3,385	1,683	3,094	2,449	1,173	3,146	2,804	1,415
Annual Energy cost savings over base, $		380	2,082		645	1,921		342	1,731
Annual Energy cost savings over base, %		10.1%	55.3%		20.8%	62.1%		10.9%	55.0%
Construction costs $	239,687	233,118	232,614	232,351	228,645	231,260	238,967	232,643	232,359
Construction cost $ > base		-6,569	-7,073		-3,706	-1,091		-6,324	-6,608
Simple Payback, years		0						0	0
Life-cycle cost, $	297,555	285,145	258,482	279,906	266,286	249,289	287,321	275,740	254,108
Life-cycle savings, $		12,410	39,073		13,620	30,617		11,581	33,213

Table 2.2. *Projected Savings.*

	ALBUQUERQUE			SALT LAKE CITY			CHEYENNE		
	Base	IECC 2000	En Star +	Base	IECC 2000	En Star +	Base	IECC 2000	En Star +
Annual energy use, MBtu	222.3	155.1	69.6	292.4	187.5	86.2	338.7	196.3	83
Annual energy savings over base, Mbtu		67.2	152.7		104.9	206.2		142.4	255.7
Annual electric use, kWh	26,463	26,766	14,257	25,361	25,354	17,803	22,084	22,203	16,629
Annual electric savings over base, kWh		-303	12,206		7	7,558		-119	5,455
Annual gas use, therms	1320	637	210	2924	1875	255	2634	1205	263
Annual gas savings over base, therms		683	1110		1049	2669		1429	2371
Annual energy cost, $	3,107	2,689	1,348	3,240	2,557	1,501	3,368	2,448	1,418
Annual Energy cost savings over base, $		418	1,759		683	1,739		920	1,950
Annual Energy cost savings over base, %		13.5%	56.6%		21.1%	53.7%		27.3%	57.9%
Construction costs $	233,102	229,236	231,247	234,297	229,576	231,180	233,357	227,173	231,823
Construction cost $ > base		-3,866	-1,855		-4,721	-3,117		-6,184	-1,534
Simple Payback, years		0	0		0	0		0	0
Life-cycle cost, $	280,857	270,566	251,966	284,096	268,877	254,250	285,123	264,799	253,618
Life-cycle savings, $		10,291	28,891		15,219	29,845		20,324	31,506

Figure 2-1 shows summary information on the three homes in the Denver area.

Figure 2-1. *Denver summary data. Note differences in the Y-axis calibrations*

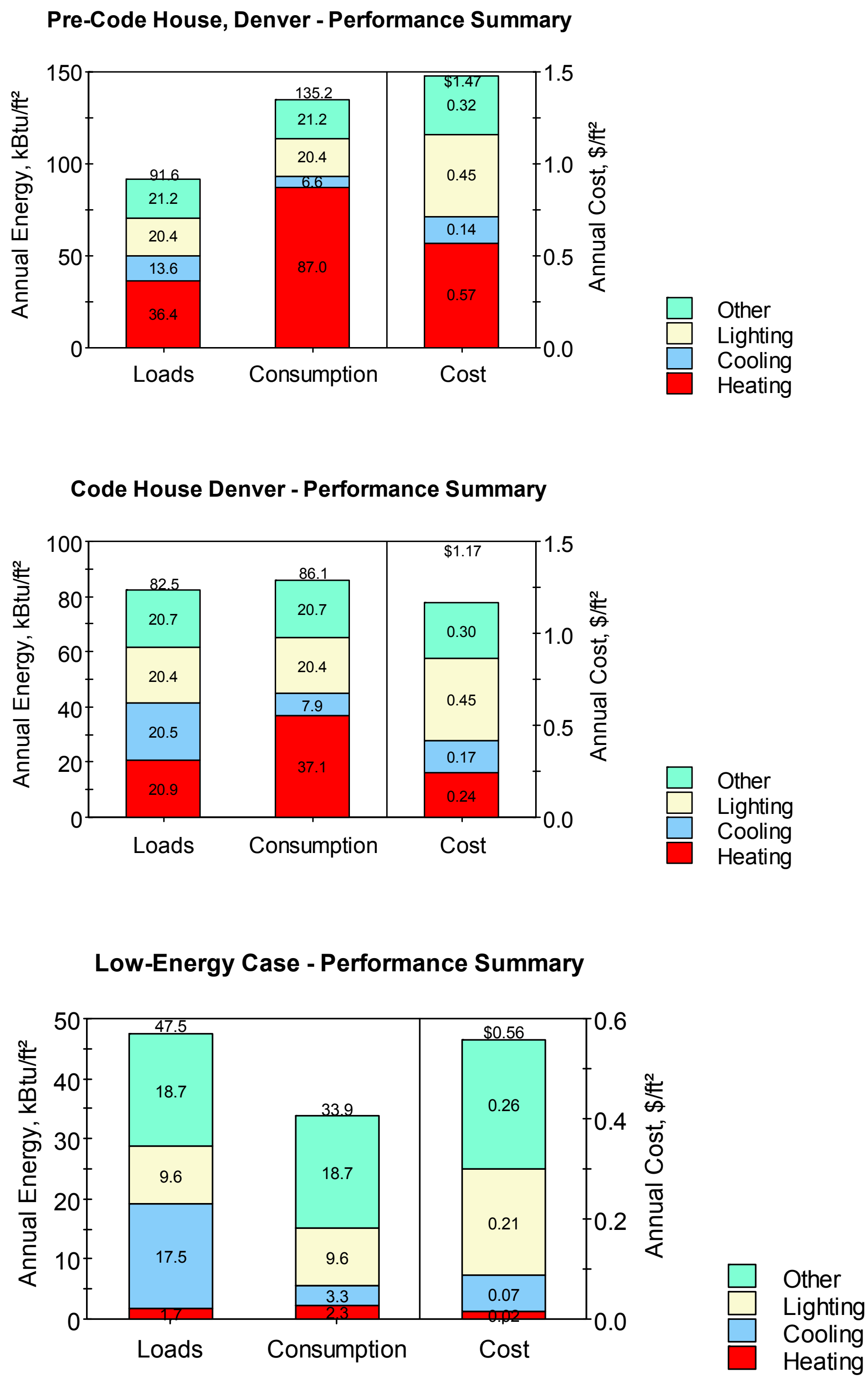

Table 2-3 shows the results of projecting the energy numbers for each state. Population and housing start projections come from census data and NEMS data.

Table 2-3. *State-by-state projections. Figures are in trillions of Btu, 10^{12} Btu's.*

ARIZONA

	Site Energy Use per Housing Unit (MBtu)
Base	182.5
IECC 2000	156.7
Energy Star+	83.5

Time Period	Projected Housing Starts	Energy Used and Saved (TBtu)				
		Base (Use)	IECC 2000		E-Star+	
			Use	Saved over Base Use	Use	Saved over Base Use
2001 – 2005	184,251	33.6	28.9	4.8	15.4	18.2
2006 – 2010	252,675	79.7	68.5	11.3	36.5	43.2
2011 – 2015	256,259	126.5	108.7	17.8	57.9	68.6
2016 – 2020	264,465	174.8	150.1	24.7	80.0	94.8
2021 – 2025	268,990	223.9	192.3	31.6	102.5	121.4

COLORADO

	Energy Use per Housing Unit (MBtu)
Base	283.9
IECC 2000	180.7
Energy Star+	71.3

Time Period	Projected Housing Starts	Energy Used and Saved (TBtu)				
		Base (Use)	IECC 2000		E-Star+	
			Use	Saved over Base Use	Use	Saved over Base Use
2001 – 2005	174,189	49.4	31.5	17.9	12.4	37.0
2006 – 2010	173,694	98.7	62.9	35.8	24.8	73.9
2011 – 2015	183,387	150.8	96.0	54.8	37.9	112.9
2016 – 2020	185,777	203.5	129.6	73.9	51.1	152.4
2021 – 2025	190,528	257.6	164.0	93.6	64.7	192.9

NEVADA

	Energy Use per Housing Unit (MBtu)
Base	188.4
IECC 2000	151.9
Energy Star+	78.9

Time Period	Projected Housing Starts	Energy Used and Saved (TBtu)				
		Base (Use)	IECC 2000		E-Star+	
			Use	Saved over Base Use	Use	Saved over Base Use
2001 – 2005	177,120	33.4	26.9	6.5	14.0	19.4
2006 – 2010	150,485	61.8	49.8	12.0	25.9	35.9
2011 – 2015	177,818	95.3	76.8	18.5	39.9	55.4
2016 – 2020	201,796	133.3	107.5	25.8	55.8	77.5
2021 – 2025	176,381	166.5	134.3	32.2	69.7	96.8

NEW MEXICO

	Energy Use per Housing Unit (MBtu)
Base	222.3
IECC 2000	155.1
Energy Star+	69.6

Time Period	Projected Housing Starts	Energy Used and Saved (TBtu)				
		Base (Use)	IECC 2000		E-Star+	
			Use	Saved over Base Use	Use	Saved over Base Use
2001 – 2005	65,336	14.5	10.1	4.4	4.5	10.0
2006 – 2010	60,933	28.0	19.6	8.4	8.7	19.3
2011 – 2015	59,353	41.2	28.8	12.4	12.8	28.4
2016 – 2020	56,545	53.8	37.6	16.2	16.7	37.1
2021 – 2025	53,382	65.7	45.9	19.8	20.4	45.3

UTAH

	Energy Use per Housing Unit (MBtu)
Base	292.4
IECC 2000	187.5
Energy Star+	86.2

Time Period	Projected Housing Starts	Energy Used and Saved (TBtu)				
		Base (Use)	IECC 2000		E-Star+	
			Use	Saved over Base Use	Use	Saved over Base Use
2001 – 2005	78,359	22.9	14.7	8.2	6.8	16.1
2006 – 2010	111,009	55.4	35.5	19.9	16.4	39.0
2011 – 2015	116,518	89.5	57.3	32.2	26.4	63.1
2016 – 2020	83,964	114.1	73.0	41.1	33.6	80.5
2021 – 2025	68,366	134.1	85.8	48.3	39.5	94.6

WYOMING

	Energy Use per Housing Unit (MBtu)
Base	338.7
IECC 2000	196.3
Energy Star+	83.0

Time Period	Projected Housing Starts	Energy Used and Saved (TBtu)				
		Base (Use)	IECC 2000		E-Star+	
			Use	Saved over Base Use	Use	Saved over Base Use
2001 – 2005	3,427	1.2	0.7	0.5	0.3	0.9
2006 – 2010	5,267	3.0	1.7	1.3	0.7	2.3
2011 – 2015	4,558	4.5	2.6	1.9	1.1	3.4
2016 – 2020	4,558	6.0	3.5	2.5	1.5	4.5
2021 – 2025	4,559	7.5	4.4	3.1	1.9	5.6

SECTION 3—RECOMMENDATIONS

Adopting and enforcing energy codes, providing training to both building inspectors and builders, evaluating actual savings achieved, and surpassing the energy performance specified by code mechanisms is probably the most effective mechanism budget-strapped states can employ to effect energy efficiency in buildings. The results of the analyses in this report and others demonstrate that far better performance than is routinely achieved with new homes is quite possible and economically sound. Each of these topics is discussed below.

Upgrade to State-of-the-Art Building Codes

State-of-the-art energy codes such as the latest version of the IECC can help states and municipalities raise energy efficiency and reduce electricity consumption and peak demand in a cost-effective manner. As noted in the discussion above, it is critical to complement code adoption with training and technical assistance as well as rigorous code enforcement efforts in order to maximize the energy savings and other benefits. These implementation-oriented activities are addressed in the second recommendation in this section.

Adopting a recent version of the IECC (i.e., 2000 or more recent) is especially important in the southwest region because this model energy code has a window efficiency requirement pertaining to maximum solar heat gain coefficient for windows (0.4) for warmer regions with 3,500 heating degree-days or less. This requirement, if followed, will lead to substantial cooling load reductions and thus air conditioning electricity use and peak demand savings in hotter states such as Arizona, New Mexico, and Nevada (Prindle and Arasteh 2001).

In the southwest region, state-of-the art building codes should be adopted statewide in New Mexico, Nevada, and Wyoming since these are not home rule states. Likewise state-of-the-art codes should be adopted at the local level where this has not yet been done in Arizona (especially in the Phoenix area) and Colorado (especially in the Denver and Colorado Springs areas) given that these are home rule states. In addition, Colorado should adopt the IECC or ASHRAE 90.1-1999 standard for all new state-owned buildings, as recommended by a commercial buildings energy efficiency advisory group that met in Colorado in 2001 (E-Star Colorado 2001). Last but not least, all of these states and localities should consider enhancing the IECC or ASHRAE standards with modifications that further improve energy efficiency in a hot, dry region, such as considering the additions to the Title 24 building standards that California adopted in 2001 (Mahone et al. 2002).

Expand Training and Technical Assistance Efforts to Achieve High Levels of Code Compliance

Training and assisting architects, builders, building contractors, and building code officials is critical to the successful implementation of new building codes. Various studies have shown that such activities can significantly improve code compliance and can be very cost-effective in terms of energy savings per program dollar (Halverson et al.

2002; Johnson and Nadel 2000; Smith and Nadel 1995; Stone et al. 2002). Training and technical assistance is needed in a variety of areas including integrated building design, proper sizing and installation of HVAC systems, proper air tightness and insulation procedures, and the use of state-of-the-art technologies and design strategies such as daylighting, duct sealing, air infiltration reduction, indirect-direct evaporative cooling, and reflective roofing options. Evaluation of homes with unvented attics is needed to confirm the effectiveness of this promising strategy.

We recommend that state energy agencies, local energy offices, and utilities in the southwest expand their efforts related to energy code implementation. Utilities in particular should support code implementation as part of their energy efficiency programs, in addition to encouraging construction of highly efficient “beyond code” new homes and commercial buildings. Utility involvement in developing and implementing codes and standards that result in energy savings can be many times as effective as conventional energy conservation programs. This is a primary conclusion of a recent study conducted by a team of researchers from the Hechong Mahone Group and the Pacific Gas and Electric Company, “What’s a Utility Codes and Standards Program Worth, Anyway?” The paper studied the consequences of using public goods funds to support work by California’s investor-owned utilities to analyze potential energy savings, market penetration potential, device availability and other issues associated with additions to California’s building and appliance standards put in place in 2001. The authors conclude that “on a per kWh basis, Codes and Standards programs cost about 2-6% of what efficiency programs cost.” (Stone et al, 2002)

Energy agencies and utilities should also consider providing technical support to building code inspectors (e.g., help in reviewing commercial building plans) and possibly providing supplementary funding to enhance code enforcement efforts in jurisdictions where such capability is limited. Building code inspectors typically have relatively little energy expertise as well as relatively little time to review energy issues during either plan reviews or field inspections (Smith and Nadel 1995).

Expand Efforts to Promote the Construction of Highly Efficient New Buildings that Exceed Minimum Code Requirements

The review of building codes and new construction programs in the region pointed out a number of examples where new homes and commercial buildings far exceed the energy performance requirements of building energy codes. This, in combination with the analysis in this report suggest that through an integrated design approach as advocated in the Energy Star® and Building American programs, it is possible to reduce energy consumption by 30 to 50 percent relative to code requirements, and do so in a cost-effective manner. This potential is not speculative; it has been proven in Civano, AZ, and in the housing developments of Ence, Pulte, and other leading builders in the region. In order to foster increased construction of highly efficient new homes and commercial buildings, energy agencies and utilities should expand technical and financial assistance efforts, demonstration and promotion programs, and performance guarantee efforts, including:

- Replication of the training, promotion, financial incentive, and energy bill guarantee programs that are leading to large numbers of highly efficient new homes in the Phoenix and Tucson areas as well as in Nevada. Programs like the one conducted by Tucson Electric Power Co. that promote 30 percent beyond-code new homes and provide builders with free inspection services merit emulation.

- Expansion and replication of exemplary commercial building new construction programs such as Utah's state buildings design assistance and incentive program or the Energy Design Assistance Program implemented in 2002 on a pilot scale by Xcel Energy in Denver. Regarding the latter, Xcel provides modeling and design support, follow-up during construction, financial incentives, and monitoring and verification assistance in order to reduce energy use in new commercial buildings by at least 30 percent relative to the level resulting from the ASHRAE 90.1-1989 minimum energy code (Xcel Energy 2002).

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